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(54) [Title of the Invention] ERASURE AGENT ERASURE CAPABILITY DETERMINATION METHOD.

(57) [Abstract]

[Issue] To provide an erasure agent erasure capability determination method whereby a determination can be easily made as to whether or not a $^1O_2$ erasure agent has the capability to eliminate $^1O_2$.

[Means of Resolution] Erasure agent erasure capability determination method wherein the respective concentrations of $^1O_2$ in multiple first mixed solutions, as well as the respective concentrations of $^1O_2$ in multiple second mixed solutions, are found and, from the concentrations of $^1O_2$ found for the respective multiple first and second mixed solutions, and from the concentrations of $^1O_2$ found in a comparison set of mixed solutions, the relationship of the elimination rates of concentrations of $^1O_2$ and the dilution rates of the erasure agent are found for the respective first and second mixed solutions; then, based on the relationship of the elimination rates of concentrations of $^1O_2$ and the erasure agent dilution rates, a determination can be made as to whether or not the erasure agent has an erasure capability.

[Scope of the Patent Claims]

[Claim 1] Erasure agent erasure capability determination method characterized as having: Step 1, at which first mixed solutions that contain prescribed, mutually different concentrations of OCl⁻ and H_2O_2 prior to the $^1O_2$ generating reciprocal reaction of these compounds are prepared by mixing each of multiple erasure agent solutions, whereby an erasure agent expected to eliminate $^1O_2$ is diluted in a prescribed solvent at multiple and mutually different dilution rates, with OCl⁻ solution and H_2O_2 solution, and then the concentrations of $^1O_2$, generated by the reaction of OCl⁻ and H_2O_2, within the first mixed solutions can be found; Step 2, at which second mixed solutions containing, prior to their reciprocal reaction, OCl⁻ and H_2O_2, whose respective concentrations are the inverse of the concentrations in the aforementioned Step 1, are prepared by mixing each of multiple erasure agent solutions formed by diluting the aforementioned erasure agent in the aforementioned prescribed solvent at multiple and mutually different dilution rates with OCl⁻ solution and H_2O_2 solution, whereupon the concentrations of $^1O_2$, generated by the reaction of OCl⁻ and H_2O_2, within the second mixed solutions are found; and Step 3, at which a determination is made as to whether or not the aforementioned erasure agent has the capability to eliminate $^1O_2$ based on the relationship of the concentrations of $^1O_2$ found in Step 1 and the aforementioned erasure agent dilution rates, and the relationship of the concentrations of $^1O_2$ found in Step 2 and the aforementioned erasure agent dilution rates.

[Claim 2] Erasure agent erasure capability determination method recorded in Claim 1 and characterized in that the step of the aforementioned Step 1 at which multiple first mixed solutions are prepared is a step at which multiple first solutions are prepared such that, prior to their reciprocal reaction, OCl⁻ and H_2O_2 are contained at concentrations whereby of the two concentrations, the higher is 30μm or less and the lower is 1/10 or less of the aforementioned higher concentration; and whereby Step 2 is a step at which multiple second mixed solutions are prepared such that, prior to their reciprocal reaction,

OCl⁻ and H_2O_2 are contained at concentrations whereby of the two concentrations, the lower concentration mentioned above has a concentration of 30μm or less, while the higher concentration above has a concentration of 1/10 or less of the abovementioned concentration.

[Claim 3] Erasure agent erasure capability determination method recorded in Claim 1 and characterized as having a Step 4 at which third mixed solutions containing OCl⁻ and H_2O_2, prior to their reciprocal reaction, at various prescribed concentrations are prepared by mixing, with the aforementioned prescribed solvent, OCl⁻ solution and H_2O_2 solution, and the concentration of $^1O_2$ in the aforementioned third mixed solutions generated by the reaction of OCl⁻ and H_2O_2 is found, and in that the aforementioned Step 3 is a step at which a determination is made as to whether or not the aforementioned erasure agent has the capability to eliminate $^1O_2$ based on the relationship of the ratio of the concentrations of $^1O_2$ found in Step 1 and the concentrations of $^1O_2$ found in Step 4 with the dilution rates of the aforementioned erasure agent, and the ratio of the concentrations of $^1O_2$ found in Step 2 and the concentrations of $^1O_2$ found in Step 4 with the dilution rates of the aforementioned erasure agent.

[Claim 4] Erasure agent erasure capability determination method recorded in Claim 1 and characterized in that the aforementioned Step 3 is a step at which a determination is made as to whether or not the aforementioned erasure agent has the capability to eliminate $^1O_2$ by comparing the transition points of concentrations on a concentration transition graph relative to the dilution rates of the aforementioned Step 1, and the transition points of concentrations on a concentration transition graph relative to the dilution rates of the aforementioned Step 2.

[A Detailed Explanation of the Invention]

[0001]

[Technical Field of the Invention]   The present invention relates to an erasure agent erasure capability determination method whereby a determination is made as to whether or not an erasure agent thought capable of eliminating $^1O_2$ is, in fact, capable of eliminating $^1O_2$.

[0002]

[Prior Art] It has been reported that active oxygens occurring naturally in the body are very closely linked to such phenomena as inflammation, the onset of cancer, aging, etc. The principle active oxygens are superoxide (-O_2), hydrogen peroxide (H_2O_2), hydroxy radical (.OH), hypochlorite ion (OCl⁻), singlet oxygen ($^1O_2$), lipid hydroperoxyl radical (LOO⁻), etc. These active oxygens are generated under physiological conditions in the life functions of plants and animals, and increases in the volume generated are brought on by stress, infection, etc. These active oxygens are highly reactive to body components and cause component breakage, tissue obstruction, and metabolism abnormalities that lead to the phenomena of inflammation, cancer, aging, etc. discussed above. Hence, it is

necessary to know the reactivity of active oxygens on various body components in order to evaluate active oxygens' effect on the body. Furthermore, the search for chemical substances to effectively eliminate active oxygens is important in developing medicines meant to suppress or block infection, cancer, aging, etc. In order to comprehend the reactivity of active oxygens on multiple body components and to detect chemical substances that effectively remove active oxygens, methods to prepare standard samples of active oxygens and methods to determine the ability to eliminate active oxygens have been developed and implemented.

[0003] Of the active oxygens listed above, $^1O_2$ has a particularly high likelihood of being generated in the body, and it is highly toxic with respect to body components. Thus, it is extremely important to find chemical substances to remove $^1O_2$.

[0004] Finding chemical substances to remove $^1O_2$ first involves that $^1O_2$ be generated, that a substance (hereafter called an "erasure agent") expected of having the capability to eliminate this generated $^1O_2$ be added and, that by monitoring the concentration of $^1O_2$ at this time, that a determination can be made as to whether or not the erasure agent has the capability to eliminate $^1O_2$. Monitoring the concentration of $^1O_2$ can occur, for example, by measuring the intensity of 1270nm wavelength light emitted in a process whereby $^1O_2$ is mitigated to a ground state oxygen (triplet oxygen: $^3O_2$).

[0005]

[Problems the Invention Endeavors to Resolve] In general, methods to generate $^1O_2$ are (1) transferring the excitation energy of optically excited photosensitive pigments to a solution-form oxygen, and (2) the mixture of H_2O_2 solution and a hypochlorite (usually sodium hypochlorite: NaOCl) solution. However, special light sources, such as lasers, etc., are needed for the excitation light source of method (1). Furthermore, expensive and complex equipment is needed for the work involved in circulating pulse radiation, etc. to suppress pigment photolysis. Moreover, because the concentrations of $^1O_2$ in the solutions differ according to the pigments, light sources, and radiation formats used, it is difficult to plan and make estimates, which is inappropriate for standard samples used to quantitatively measure $^1O_2$. On the other hand, method (2) has long been used because this method can generate $^1O_2$ far more cheaply than method (2), and this reaction has undergone chemical verification. However, when $^1O_2$ is generated by method (2) and the $^1O_2$ is to be eliminated by an erasure agent, that erasure agent will eliminate the raw materials to generate $^1O_2$ if it is capable of eliminating not only $^1O_2$ but also either of OCl$^-$ and H_2O_2 and, from appearances, the result will be the same as if the erasure agent had eliminated $^1O_2$. In short, a method using NaOCl solution and H_2O_2 solution can generate $^1O_2$ inexpensively, but the problem is the extreme difficulty of determining whether or not the erasure agent has the capability to erase $^1O_2$.

[0006] Taking into consideration the aforementioned facts, the objective of the present invention is to provide an erasure agent erasure capability determination method whereby a determination can be made easily as to whether or not as erasure agent has the capability to eliminate $^1O_2$.

[0007]

[Means to Resolve Problems] The erasure agent erasure capability determination method of the present invention that achieves the aforementioned objective is characterized as having:

(1) Step 1, at which first mixed solutions that contain prescribed, mutually different concentrations of OCl^- and H_2O_2 prior to the $^1O_2$ generating reciprocal reaction of these compounds are prepared by mixing each of multiple erasure agent solutions, in which an erasure agent expected to eliminate $^1O_2$ is diluted in a prescribed solvent at multiple and mutually different dilution rates, with OCl^- solution and H_2O_2 solution, and then the concentrations of $^1O_2$, generated by the reaction of OCl^- and H_2O_2, within the first mixed solutions can be found;

(2) Step 2, at which second mixed solutions containing, prior to their reciprocal reaction, OCl^- and H_2O_2 and whose respective concentrations are the inverse of the concentrations in the aforementioned Step 1 are prepared by mixing each of the multiple erasure agent solutions formed by diluting the aforementioned erasure agent in the aforementioned prescribed solvent at multiple and mutually different dilution rates with OCl^- solution and H_2O_2 solution, and then the concentrations of $^1O_2$, generated by the reaction of OCl^- and H_2O_2, within the second mixed solutions can be found;

(3) Step 3, at which a determination is made as to whether or not the aforementioned erasure agent has the capability to eliminate $^1O_2$ based on the relationship of the concentrations of $^1O_2$ found in Step 1 and the aforementioned erasure agent dilution rates, and the relationship of the concentrations of $^1O_2$ found in Step 2 and the aforementioned erasure agent dilution rates.

[0008] In the present invention, the respective concentrations of OCl^- and H_2O_2 contained in the second mixed solutions prepared in Step 2 are, prior to the reciprocal reaction of OCl^- and H_2O_2, the inverse of these concentrations found in the first mixed solutions prepared in Step 1. Thus, when the first and second mixed solutions are prepared, and the erasure agent is, from among the group OCl^-, H_2O_2, and $^1O_2$, capable only of eliminating $^1O_2$, the respective volumes of $^1O_2$ in the first and second mixed solutions are about even. However, if the erasure agent is capable of eliminating OCl^- or H_2O_2, the respective volumes of $^1O_2$ in the first and second mixed solutions will differ. In short, the respective relationships of the concentrations of $^1O_2$ found in the Steps 1 and 2 differ according to whether or not the erasure agent is capable of eliminating $^1O_2$. Hence, by comparing the relationship of the concentrations of $^1O_2$ found at Step 1 and the erasure agent dilution rates to the relationship of the concentrations of $^1O_2$ found at Step 2 and the erasure agent dilution rates, a determination can be made as to whether or not the erasure agent has the capability to eliminate $^1O_2$. Furthermore, if the erasure agent has the capability to eliminate OCl^- or H_2O_2, the size relationship of the volume of $^1O_2$ in the first

and second mixed solutions, respectively, inverts according to whether or not the erasure agent has the capability to eliminate OCl^- or whether or not the erasure agent has the capability to eliminate H_2O_2. Hence, by comparing the relationship of the concentrations of $^1O_2$ found at Step 1 and Step 2 to the erasure agent dilution rates, with the relationship of the concentrations of $^1O_2$ found at Step 2 to the erasure agent dilution rates, not only can a determination be made as to whether or not the erasure agent has the capability to eliminate $^1O_2$, but a determination can also be made as to whether or not this erasure agent has the capability to eliminate OCl^- or H_2O_2.

[0009] In the aforementioned Step 1 of the erasure agent erasure capability determination method of the present invention, it is preferred that multiple aforementioned first mixed solutions be prepared wherein OCl^- and H_2O_2 are contained, prior to their reciprocal reaction, at concentrations where the higher of the two is 30μm or less and the lower of the two is 1/10 or less of the aforementioned concentration, and that the aforementioned Step 2 is one at which multiple aforementioned second mixed solutions are prepared such that OCl^- and H_2O_2 are contained, prior to their reciprocal reaction, with the aforementioned lower concentration now being the aforementioned higher concentration of 30μm or less, and the aforementioned lower concentration now being 1/10 or less of the aforementioned concentration.

[0010] When OCl^- and H_2O_2 react and $^1O_2$ is generated, the process of $^1O_2$ mitigating into triplet $^3O_2$ ground state oxygen is accompanied by light emission in the 1300nm band. This 1300nm band light is received by light receiving elements. By determining the volume of light received by light receiving elements, the generated $^1O_2$ can be measured quantitatively. However, when a reaction is caused between OCl^- and H_2O_2, usually the $^1O_2$ generating reaction concludes within approximately 0.5 seconds when, for example, the mixed solutions prepared prior to the reciprocal reaction of OCl^- and H_2O_2 contains each at a concentration of several millimoles. In short, after preparing the mixed solutions, the $^1O_2$ generating reaction terminates within 0.5 seconds, and the $^1O_2$ that has not been eliminated by the erasure agent and that remains in the mixed solutions is mitigated almost simultaneously, 1300nm band light is emitted, and the concentration of $^1O_2$ becomes low quickly. For this reason, the time that 1300nm band light is emitted is extremely brief, the receipt of light in a stable manner by the light receiving elements is complex, and measurement of $^1O_2$ is a quantitative manner is difficult. By contrast, with the concentration of one from among OCl^- and H_2O_2 being 30μm or less, and the concentration of the other being 1/10 of less of the aforementioned concentration, prior to their reciprocal reaction, it becomes difficult for the concentration of $^1O_2$ remaining in the mixed solution and not eliminated by the erasure agent to be low. Hence, the time that faint 1300nm band light is emitted in the process of $^1O_2$ mitigating to $^3O_2$ can be longer than the time that faint 1300nm band light is emitted in mixed solutions containing OCl^- and H_2O_2 at concentrations of several millimoles. Hence, the light receiving elements can receive light stably, and the quantitative measurement of $^1O_2$ can occur easily.

[0011] Here, the erasure agent erasure capability determination method involves preparing third mixed solutions that contain OCl^- and H_2O_2 at various prescribed, mutually different concentrations, prior to the reciprocal reaction of OCl^- and H_2O_2' with

the aforementioned prescribed solvent, OCl⁻ solution, and H_2O_2 solution. There is also a Step 4 wherein the concentration of $^1O_2$ inside the aforementioned third mixed solutions is found, and the aforementioned Step 3 is preferably a step at which a determination is made as to whether or not the aforementioned erasure agent has the capability of eliminating $^1O_2$ based upon the relationship of the ratio of the concentrations of $^1O_2$ found in the aforementioned Step 1 and the concentrations of $^1O_2$ found in the aforementioned Step 4 to the dilution rates of the aforementioned erasure agent, and upon the relationship of the ratio of the concentrations of $^1O_2$ found in the aforementioned Step 2 and the concentrations of $^1O_2$ found in the aforementioned Step 4 to the dilution rates of the aforementioned erasure agent.

[0012] The mixed solutions prepared in Step 4 contain no erasure agent. Hence, a determination can be made easily as to whether or not the erasure agent has an erasure capability by comparing the respective concentrations of $^1O_2$ found in the respective Steps 1 and 2, to the concentration of $^1O_2$ found in the aforementioned Step 4.

[0013] In the erasure agent erasure capability determination method of the present invention, it is desirable that the aforementioned Step 3 be a step at which a determination can be made as to whether or not the aforementioned erasure agent has the capability to eliminate $^1O_2$ by comparing concentration transition points on the concentration transition graph relative to the dilution rates, in the aforementioned Step 1, to the concentration transition points on the concentration transition graph relative to dilution rates, in the aforementioned Step 2.

[0014] In addition to the graph depiction of concentration transitions relative to dilution rates in the aforementioned Step 1, concentration transitions relative to dilutions rates in the aforementioned Step 2 are also depicted on a graph. By comparing the relative axial positions of the dilution rates of the concentration transition points on each of the aforementioned graphs, a determination can be made as to whether or not the erasure agent has the capability to eliminate $^1O_2$.

[0015]

[Embodiments] Following is an explanation of an embodiment of the present invention.

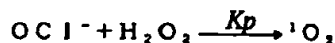[0016] First, NaOCl solution and H_2O_2 solution are prepared. In solution:

[0017]

[No. 1] ... (1)

$$NaOCl \rightarrow Na^+ + OCl^-$$

[0018] is the form into which NaOCl dissociates. When this OCl⁻ reacts with H_2O_2, $^1O_2$ generates in the manner shown in Formula (2):

[0019]

[No. 2] ... (2)

$$OCl^- + H_2O_2 \xrightarrow{Kp} {}^1O_2$$

[0020] Here, kp of Formula (2) is a chemical constant.

[0021] After Formula (1) and Formula (2), ${}^1O_2$ is generated by mixing together NaOCl solution and H_2O_2 solution. In short, NaOCl solution and H_2O_2 solution are the raw materials to generate ${}^1O_2$. In the present invention, moreover, in order to generate ${}^1O_2$ in the manner shown in Formula (2), OCl⁻ is needed in addition to H_2O_2, and in this embodiment NaOCl solution is used in order to generate this OCl⁻. However, another solution that generates OCl⁻ can be used instead of NaOCl solution.

[0022] Then, in addition to the NaOCl solution and the H_2O_2 solution, erasure agent solutions are prepared wherein an erasure agent is dissolved to a high concentration in a prescribed solvent. These prepared erasure agent solutions, NaOCl solution, and H_2O_2 solution are then mixed to prepare first mixed solutions wherein, prior to their reciprocal reaction, OCl⁻ and H_2O_2 are contained at concentrations of 30μm and 0.67μm, respectively (in short, the concentration of OCl⁻ is high and the concentration of OCl⁻ [sic.] is low). Since NaOCl solution and H_2O_2 solution are contained in this first mixed solution, OCl⁻ and H_2O_2 react as discussed above and ${}^1O_2$ is generated. As shown by the following formula, this generated ${}^1O_2$ mitigates into a ground state oxygen (triplet oxygen: ${}^3O_2$) and emits 1300nm wavelength band light.

[0023]

[No. 3] ... (3)

$$ {}^1O_2 \xrightarrow{Kd} {}^3O_2 + 1300 nm\ band\ light $$
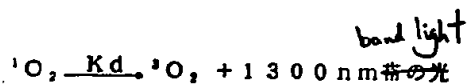
[0024] In this case, kd in Formula (3) is a chemical constant.

[0025] In the embodiment, this 1300nm band light is received. Based on the volume of light received, the concentration of ${}^1O_2$ that is not eliminated by the erasure agent and that remains in the first mixed solutions is found. As discussed above, though, these first mixed solutions are prepared such that the concentrations of OCl⁻ and H_2O_2 are, respectively, 30μm and 0.67μm prior to their reciprocal reaction. In general, in mixed solutions that contain OCl⁻ and H_2O_2, the higher of the two concentrations among OCl⁻ and H_2O_2 is set at 30μm or less, and the lower concentration is set at 1/10 or less of the higher concentration. It is then difficult for the concentrations of ${}^1O_2$ generated in the mixed solution to be low (in a mixture that, in addition to OCl⁻ and H_2O_2, contains an erasure agent, the concentrations of ${}^1O_2$ that remain in the mixed solution after not being eliminated by the erasure agent). When, in this manner, it becomes difficult for the concentrations of ${}^1O_2$ to be low, radiation of 1300nm band light occurs over several

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seconds, light receiving elements can receive the light stably, and it is then easy to measure $^1O_2$ quantitatively.

[0026] Following is an explanation, with Figure 1 as a reference, that demonstrates the difficulty of the concentrations of $^1O_2$ becoming low in mixed solutions containing OCl⁻ and H_2O_2 when the higher of the two concentrations is set at 30μM or less and the lower is set at 1/10 of the higher concentration.

[0027] Figure 1 is an explanatory graph of same.

[0028] This graph shows the changes in concentrations of $^1O_2$ when mixed solutions containing OCl⁻ and H_2O_2 are mixed so that the concentrations of OCl⁻ and H_2O_2 are, respectively, 30μm and 0.67μm prior to the reciprocal reaction of OCl⁻ and H_2O_2. Here, the mixed solutions are prepared by mixing NaOCl solution, H_2O_2 solution, and a prescribed solvent (in other words, the mixed solutions contain no erasure agent).

[0029] The horizontal axis of the graph is time elapsed after mixing the NaOCl solution, the H_2O_2 solution, and the prescribed solvent. The left vertical axis is the intensity of 1300nm band light emitted from the mixed solutions. The right vertical axis are the concentrations of $^1O_2$.

[0030] At an elapsed time of 0.2 seconds, the concentrations of $^1O_2$ are about 0.26pM and, at 5 seconds, 0.17pM. It is thus understood that the concentrations of $^1O_2$ 5 seconds after the NaOCl solution, the H_2O_2 solution, and the prescribed solvent are mixed is maintained at a level of about 70% of the concentration of $^1O_2$ immediately after mixing. However, when a mixed solution containing OCl⁻ and H_2O_2 is prepared and causes $^1O_2$ to generate, then, before the reciprocal reaction of OCl⁻ and H_2O_2, if the one among OCl⁻ and H_2O_2 in the mixed solutions having the higher concentration has a prescribed concentration of several millimoles or more, the concentration of $^1O_2$ 5 seconds after the mixture of NaOCl solution, H_2O_2 solution, and the prescribed solvent diminishes to about 20% or less of the concentration immediately after mixing. By contrast, by setting the higher concentration among OCl⁻ and H_2O_2 at 30μm or less and the lower concentration at 1/10 or less of the higher concentration, as mentioned above, it is difficult for the concentration of $^1O_2$ to become low, as shown in Figure 1. The first mixed solutions are prepared, as described above, such that OCl⁻ and H_2O_2 are contained at concentrations of 30μm and 0.67μm, respectively, prior to the reciprocal reaction of OCl⁻ and H_2O_2. Hence, it becomes difficult for the concentration of the remaining $^1O_2$ not eliminated by the erasure agent to be low. The reasons for this difficulty in the concentration of $^1O_2$ becoming lower are believed to be as follows.

[0031] Prior to the reciprocal reaction of OCl⁻ and H_2O_2 in a mixed solutions containing OCl⁻ and H_2O_2, the concentrations of $^1O_2$ in these mixed solutions are expressed by the following formula, there being a sufficiently large difference between the concentrations of OCl⁻ and H_2O_2 and, of them, A being the one of higher concentration and B the one of lower concentration..

[0032]

[No. 4] ... (4)

$$({}^1O_2 \text{ concentration}) = \frac{kp}{kd} \cdot A \cdot B \; (e^{-(kp)/n} - e^{-(kd)/t})$$

[0033] Here, kp and kd are the chemical constants for formula (2) and formula (3), respectively. T is time elapsed after mixing of OCl⁻ and H_2O_2. With formula (4), time changes in the concentrations of ${}^1O_2$ within mixed solutions containing OCl⁻ and H_2O_2 depend on concentration A, which is toward the higher side. Hence, the lower the value of higher concentration A, the more difficult it is for the concentration of ${}^1O_2$ relative to time to be low.

[0034] By making it difficult in this manner for the concentration of ${}^1O_2$ to be low, the radiation of light shown in formula (3) occurs over several seconds, light can be received stably by the light-receiving elements, and quantitative measurement of ${}^1O_2$ in the first mixed solutions can occur easily.

[0035] Also, the comparison set mixed solutions containing no erasure agent but which contain OCl⁻ and H_2O_2 are prepared. These mixed solutions are prepared by using a solution to dilute the aforementioned erasure agent, NaOCl solution, and H_2O_2 solution such that OCl⁻ and H_2O_2 are contained at concentrations of 30μm and 0.67μm, respectively, prior to the reciprocal reaction of OCl⁻ and H_2O_2. The concentration S_C of ${}^1O_2$ in the comparison set mixed solutions prepared in this manner is found. In this case, moreover, the comparison set mixed solutions are prepared so as to contain concentrations of OCl⁻ and H_2O_2 at 30μm and 0.67μm, respectively. However, they may also be prepared such that concentrations of OCl⁻ and H_2O_2 contained are, conversely, 0.67μm for OCl⁻ and 30μm for H_2O_2.

[0036] After finding the concentration S_T of ${}^1O_2$ in the first mixed solutions prepared as described above and the concentration S_C of ${}^1O_2$ in the comparison set mixed solutions, the erasure rate of ${}^1O_2$ is found according to the following formula.

[0037]

[No. 5] ... (5)

$$\frac{S_c - S_T}{S_c} \times 1\,0\,0 \;\; (\%)$$

[0038] In cases where an erasure rate found using formula (5) exceeds a prescribed value, the erasure capability of the erasure agent is deemed to be substantial. At this stage, it is unknown whether or not the erasure agent has the capability to eliminate any from among OCl⁻, H_2O_2 and ${}^1O_2$. When the erasure capability of the erasure agent is deemed to be substantial, that erasure agent is deemed to have the capability to eliminate any from among OCl⁻, H_2O_2 and ${}^1O_2$.

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[0039] Following is an explanation about a method to determine whether or not an erasure agent has the capability to eliminate any from among OCl^-, H_2O_2 and $^1O_2$.

[0040] Multiple first mixed solutions prepared to contain OCl^- and H_2O_2 at concentrations of 30μM and 0.67μm, respectively, are prepared by changing the dilution rates of the erasure agent contained in the erasure agent solutions. At this time, preparation occurs so as to contain erasure agent solutions wherein the erasure agent is dissolved until the $^1O_2$ erasure rate becomes approximately 0%. Specifically, each of the various erasure agent solutions wherein the erasure agent is dissolved at multiple, mutually different dilution rates is mixed with H_2O_2 solution and NaOCl solution. The respective concentrations of $^1O_2$ in the multiple first mixed solutions prepared in this manner are found. The respective concentrations of $^1O_2$ are substituted for S_T in Formula (5). In addition, the concentrations of $^1O_2$ found earlier of the comparison set mixed solutions are substituted for S_C, and then the $^1O_2$ erasure rate is found for each of the multiple first mixed solutions. Also, before the reaction of OCl^-, and H_2O_2, the aforementioned first mixed solutions are prepared to have an OCl^- concentration at 30μm and a NaOCl concentration at 0.67μm. However this time, conversely, second mixed solutions are prepared in multiples by mixing each of the aforementioned multiple erasure solutions with H_2O_2 solution and NaOCl solution so that, prior to reaction of OCl^- and H_2O_2, the OCl^- concentration is 0.67μm and the NaOCl concentration is 30μm (in short, the concentration of OCl^- becomes low and the concentration OCl^- [*sic.*] becomes high). The concentration of $^1O_2$ in each of the multiple second mixed solutions prepared in this way is found. Each concentration of $^1O_2$ is substituted for S_T in formula (5), the concentrations of $^1O_2$ found earlier of the comparison set mixed solutions are substituted for S_C, and then the $^1O_2$ erasure rate is found for each of the multiple second mixed solutions.

[0041] Figure 2 depicts the relationships between the various erasure rates of $^1O_2$ in the multiple first and second mixed solutions found in the manner described earlier and the dilution rates of the erasure agent contained in the erasure agent solution.

[0042] Bar graph I expresses the relationship between the erasure rates of $^1O_2$ in the multiple first mixed solutions found in the manner described earlier and the dilution rates of the erasure agent contained in the erasure agent solutions, and bar graph II is a graph expressing the relationship between erasure rates of $^1O_2$ in the multiple second mixed solutions found in the manner described earlier and the dilution rates of the erasure agent contained in the erasure agent solutions. The horizontal axis in both bar graphs I and II is the dilution rate of the erasure agent contained in the erasure agent solutions used to prepare the first and second mixed solutions (the concentration of erasure agent contained in the erasure agent solution), while the vertical axis is the erasure rate of $^1O_2$. Figure 2 shows three patterns (a, b and c) expressing the relative relationships between bar graphs I and II, depending on which among OCl^-, H_2O_2 and $^1O_2$ the erasure agent has the capability to eliminate.

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[0043] For each of these three patterns (a, b, and c), the dilution rate range when the erasure rate E of bar graphs I and II changes to $0\% < E < 100\%$ (hereafter referred to as the erasure elimination range of this dilution ratio range) R_E is found.

[0044] Here, prior to the reciprocal reaction of OCl^- and H_2O_2, the concentrations of OCl^- and H_2O_2 contained in the first mixed solutions, and the concentrations of OCl^- and H_2O_2 contained in the second mixed solutions, are mutually reversed. Hence, hypothesizing that no erasure agent is mixed into either the first or the second mixed solutions, the concentrations of $^1O_2$ generated in the first and second mixed solutions are analogous. Therefore, the patterns that indicate the relative relationship between bar graphs I and II differ depending on which among OCl^-, H_2O_2 and $^1O_2$ the erasure agent has the capability to eliminate. Specifics in this regard follow.

[0045] In pattern a, the positions of the erasure capability elimination range R_E relative to the dilution-rate expressing horizontal axis match in bar graphs 1 and II. In short, when the dilution rates of the erasure agents contained in the erasure agent solutions used in preparing the first and second mixed solutions are equal, the erasure rates of $^1O_2$ for the first and second mixed solutions are about equal. Hence, a determination is made that among OCl^-, H_2O_2 and $^1O_2$, the erasure agent has the capability to eliminate $^1O_2$.

[0046] In pattern b, the position of the erasure capability elimination range R_E relative to the dilution-rate expressing horizontal axis of bar graph II is shifted to the high dilution rate side relative to bar graph I. In short, for the erasure rate in the second mixed solutions to approach zero, the dilution rate of the erasure agent contained in the erasure agent solutions must be greater than in the first mixed solutions, and the concentrations of erasure agent must be lower. Hence, a determination can be made as to whether or not an erasure agent has, among OCl^- and H_2O_2, an erasure capability relative to OCl^-, which has a low concentration in the second mixed solutions.

[0047] Also, unlike pattern b, the position of the erasure capability elimination range R_E relative to the dilution-rate expressing horizontal axis of bar graph I is, in pattern c, shifted to the high dilution rate side relative to bar graph II. In short, for the erasure rate in the first mixed solutions to approach zero, the dilution rate of the erasure agent contained in those erasure agent solutions must be greater than in the second mixed solutions, and the concentration of the erasure agent must be lower. A determination can thus be made as to whether or not the erasure agent has, among OCl^- and H_2O_2, an erasure capability relative to H_2O_2, which has a low concentration in the first mixed solutions.

[0048] In this manner then, with Figure 2 as a reference, a determination can be made as to whether or not an erasure agent has the capability to eliminate any from among OCl^-, H_2O_2, and $^1O_2$. Moreover, in this embodiment, as expressed by the bar graphs of Figure 2, multiple first and second solutions are prepared, using multiple erasure agent solutions wherein an erasure agent is diluted at different dilution rates, in order to find the relationship between the dilution rate and the erasure rate of $^1O_2$. Although these mixed

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solutions are prepared in the order of first mixed solutions followed by second mixed solutions, the order in which these mixed solutions are prepared may be reversed.

[0049] Incidentally, in the aforementioned method, when determining whether or not an erasure agent has the capability to eliminate any from among OCl^-, H_2O_2, and $^1O_2$, the concentration of the erasure agent is conditioned by the concentrations of OCl^- and H_2O_2 within the first and second mixed solutions. For example, when the sensitivity of the detector that detects 1300nm range light emitted in the process of mitigating $^1O_2$ into a base state oxygen is low, the concentrations of OCl^- and H_2O_2 must be high. However, if the erasure agent concentration is clearly low compared to the concentrations of OCl^- and H_2O_2, a determination cannot be made as to which of them this erasure agent has the capability to eliminate, even if an erasure agent has the capability to eliminate any from among OCl^-, H_2O_2, and $^1O_2$. Hence, the concentration of erasure agent in the mixed solutions must be high.

[0050] In the embodiment, moreover, in addition to the concentrations of $^1O_2$ in the first and second mixed solutions, comparison set mixed solutions are prepared, the concentrations of $^1O_2$ in the comparison set mixed solutions are found, and the erasure rate is calculated from these found concentrations of $^1O_2$. From the relationship between this erasure rate and the dilution rate, a determination is made as to whether or not the erasure agent has the capability to eliminate any from among OCl^-, H_2O_2, and $^1O_2$. However, the relationship between the erasure agent dilution rate and the $^1O_2$ concentrations found for the first mixed solutions, and the relationship between the erasure agent dilution rate and the $^1O_2$ concentrations found for the second mixed solutions, differ according to whether or not the erasure agent has the capability to eliminate any from among OCl^-, H_2O_2, and $^1O_2$. Hence, even if the concentrations of $^1O_2$ in the comparison set mixtures are not found, a determination can be made as to whether or not the erasure agent has the capability to eliminate any from among OCl^-, H_2O_2, and $^1O_2$ based on the relationship between the erasure agent dilution rate and the concentrations of $^1O_2$ found for the first and second mixed solutions.

[0051] In the embodiment, moreover, the positions of the erasure capability elimination ranges R_E related to the dilution-rate expressing horizontal axes of bar graphs I and II are compared, and a determination is made as to whether or not the erasure agent has the capability to eliminate any from among OCl^-, H_2O_2, and $^1O_2$. However, instead of comparing the positions of the erasure capability elimination ranges R_E, a determination can also be made as to whether or not an erasure agent has the capability to eliminate any from among OCl^-, H_2O_2, and $^1O_2$ by, for example, comparing common points at which the erasure rates change when the dilution rates reach a maximum (minimum) value within the erasure capability elimination ranges R_E in bar graphs I and II, or comparing common points at which the erasure rate changes when the dilution rates reach a middle value (namely 50%) within the erasure capability elimination ranges R_E in bar graphs I and II, and so on.